FERMILAB TO HOMESTAKE

Milind Diwan

Physics Advisory Committee
March 5-6, 2009
Fermilab

Recent Milestones

* Oct. 15, First collaboration meeting at BNL. Oct.16-17 UDIG workshop.
* Nov 3-5, 2008, Talk from Bob Svoboda to this PAC.
* Dec. 2, Collaboration adapts a vision statement to clarify the scientific scope.
* Dec. 27, Collaboration completes a document for justifying the depth of the detector.
* Jan. 9, 2009 Completion and submission of the S4 proposal to NSF. An important organizational exercise.
* Jan. 2009, First year NSF review of DUSEL chaired by Ed. Temple.
* February, 2009, discussion of project management structure and plans for DOE CD1
* February 26-28, 2009 Collaboration meeting at UC Davis. Discussion of the budgets for CD1.
* The FNAL DUSEL beamline working group (chair: Jeff. Appel) has been meeting for >6 months.

People

and many others ...

Science First.

* The depth document justifies the depth of 4850 ft for physics.

* The depth document also lists site dependent engineering issues.

* FNAL-TM-2424-E, BNL-81896-2008-IR, LBNL-1348E

Rate(Hz)	In-time cosmics/yr	Depth (mwe)
500 kHz	5×10^7	0
3 kHz	300,000	265
400 Hz	40,000	880
5 Hz	500	2300
1.3 Hz	130	2960
0.60 Hz	60	3490
0.26 Hz	26	3620
0.09 Hz	9	4290

Rate into a 50m diaX50m high detector

← 4850 ft Homestake

Physics	Water	Argon
Long-Baseline Accelerator	1000 mwe	0-1000 mwe
$p \rightarrow K^+ \bar{\nu}$	>3000 mwe	>3000 mwe
Day/Night ^{8}B Solar ν	~4300 mwe	~4300 mwe
Supernova burst	3500 mwe	3500 mwe
Relic supernova	4300 mwe	> 2500 mwe
Atmospheric ν	2400 mwe	2400 mwe

Background issues

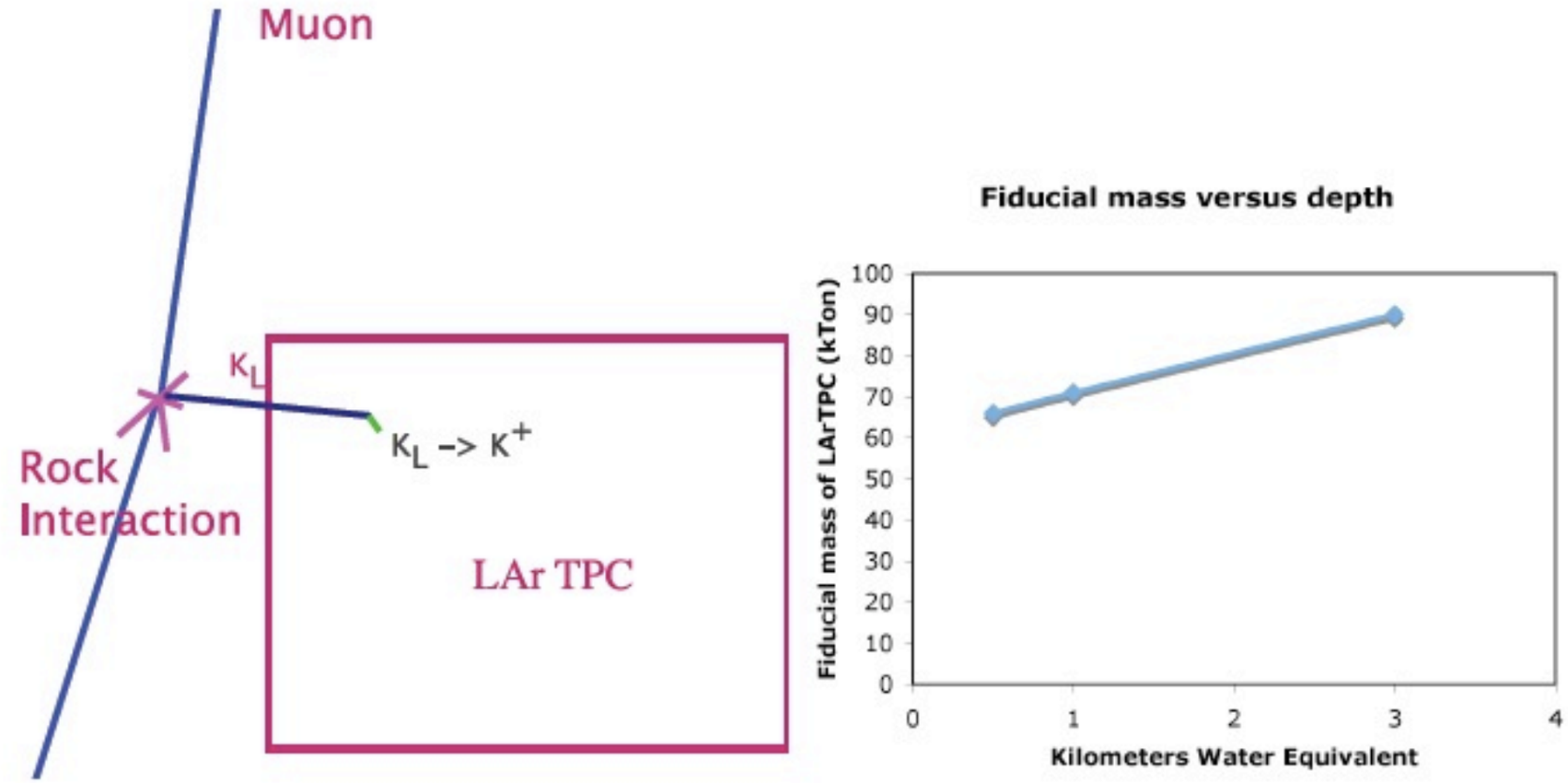
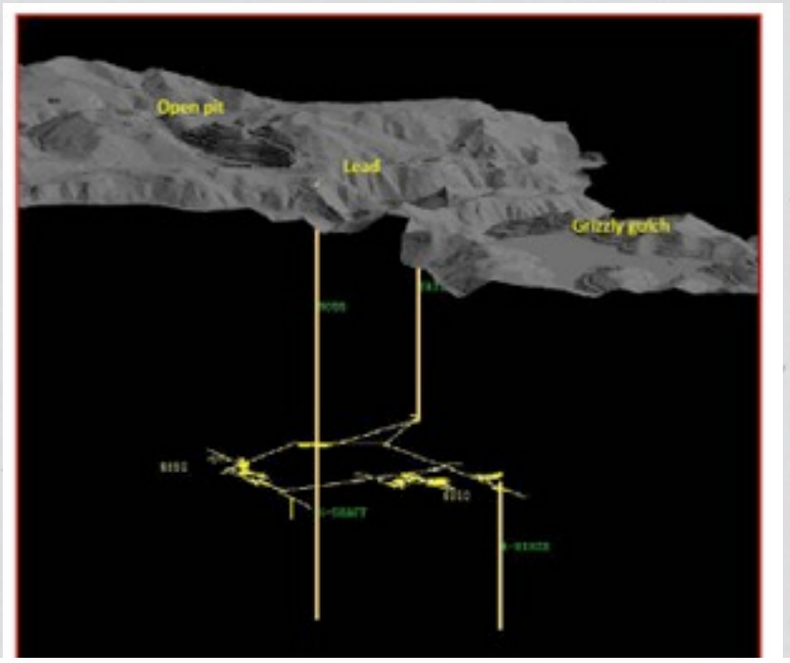
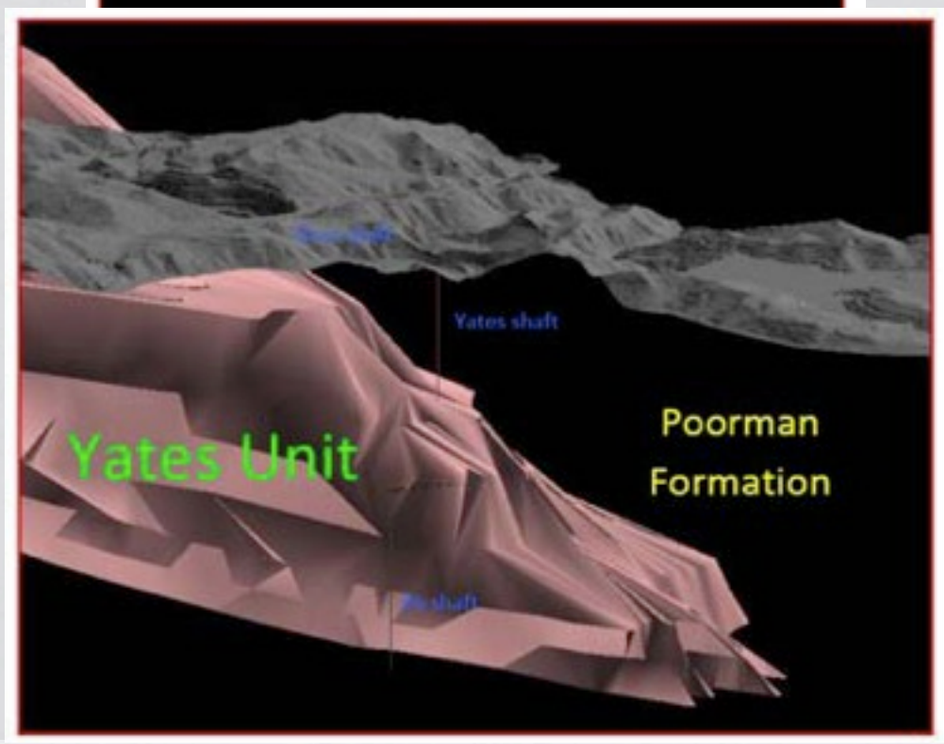


FIG. 8: Schematic illustrating a possible background for the $p \to \bar{\nu} K^+$ mode in which a neutral kaon is generated by muon interaction in rock (left). Right hand side shows the fiducial volume that can be retained to reject this cosmogenic background down to 0.1 events/year for a liquid argon TPC with a total mass of 100 kTon in a single module [13].

Siting criteria at Homestake

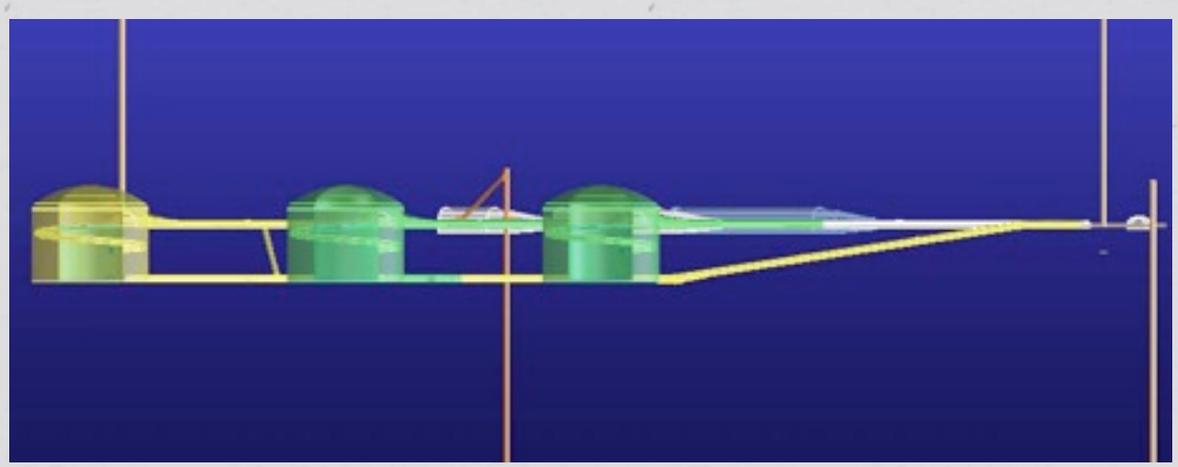
1.Above or at 4850L.
2.Ross-Yates access.
3.Excavations in Yates at a single level.
4.Existing Waste Rock facilities
5.Room for ≥3 cavities.
6.Support Life Safety & Hazard mitigation.
7.Avoid areas of high stress.
8.Avoid Formation Contacts.
9.Avoid Significant geo-structural features (shear or fracture zones)

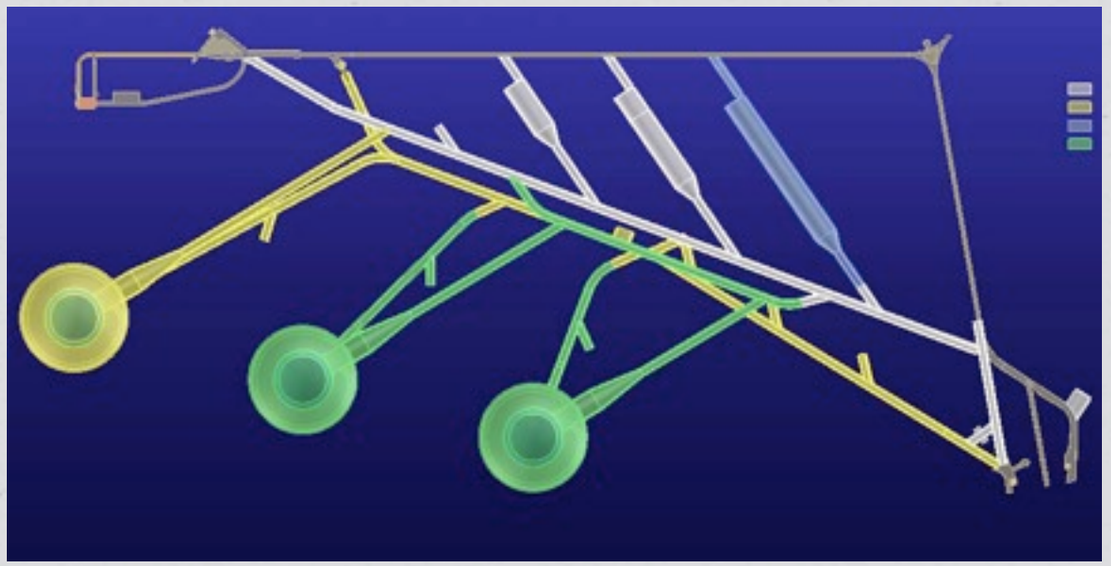




Site consideration conclusion

None of the physics signatures requires a depth greater than the ~4850 ft level at Homestake (~4300 meters-water-equivalent). We therefore recommend that geotechnical studies for the large detector be carried out at the 4850 ft level as soon as possible. This depth is sufficient to carry out an excellent physics program, and takes the best advantage of the infrastructure and rock conditions at the Homestake Mine.





Credits

Fermilab-TM-2424-E, BNL-81896-2008-IR, LBL-1348E

Report on the Depth Requirements for a Massive Detector at Homestake

Adam Bernstein,[1] Edward Blucher,[2] David B. Cline,[3] Milind V. Diwan,[4] Bonnie Fleming,[5] Richard Kadel,[6] Edward Kearns,[7] Joshua Klein,[8] Kenneth Lande,[8] Francesco Lanni,[4] David Lissauer,[4] Robert McKeown,[9] William Morse,[4] Regina Rameika,[10] Kate Scholberg,[11] Michael Smy,[12] Henry Sobel,[12] Gregory Sullivan,[7] Robert Svoboda,[13] Mark Vagins,[14] Christopher Walter,[11] and Robert Zwaska[15]

[1]*Lawrence Livermore National Laboratory, Livermore, CA 94550*

[2]*Department of Physics, University of Chicago, Chicago, IL 60637*

[3]*Department of Physics, University of California, Los Angeles, CA 90095*

[4]*Department of Physics, Brookhaven National Laboratory, Upton, NY 11973*

[5]*Department of Physics, Yale University, New Haven, CT 06520*

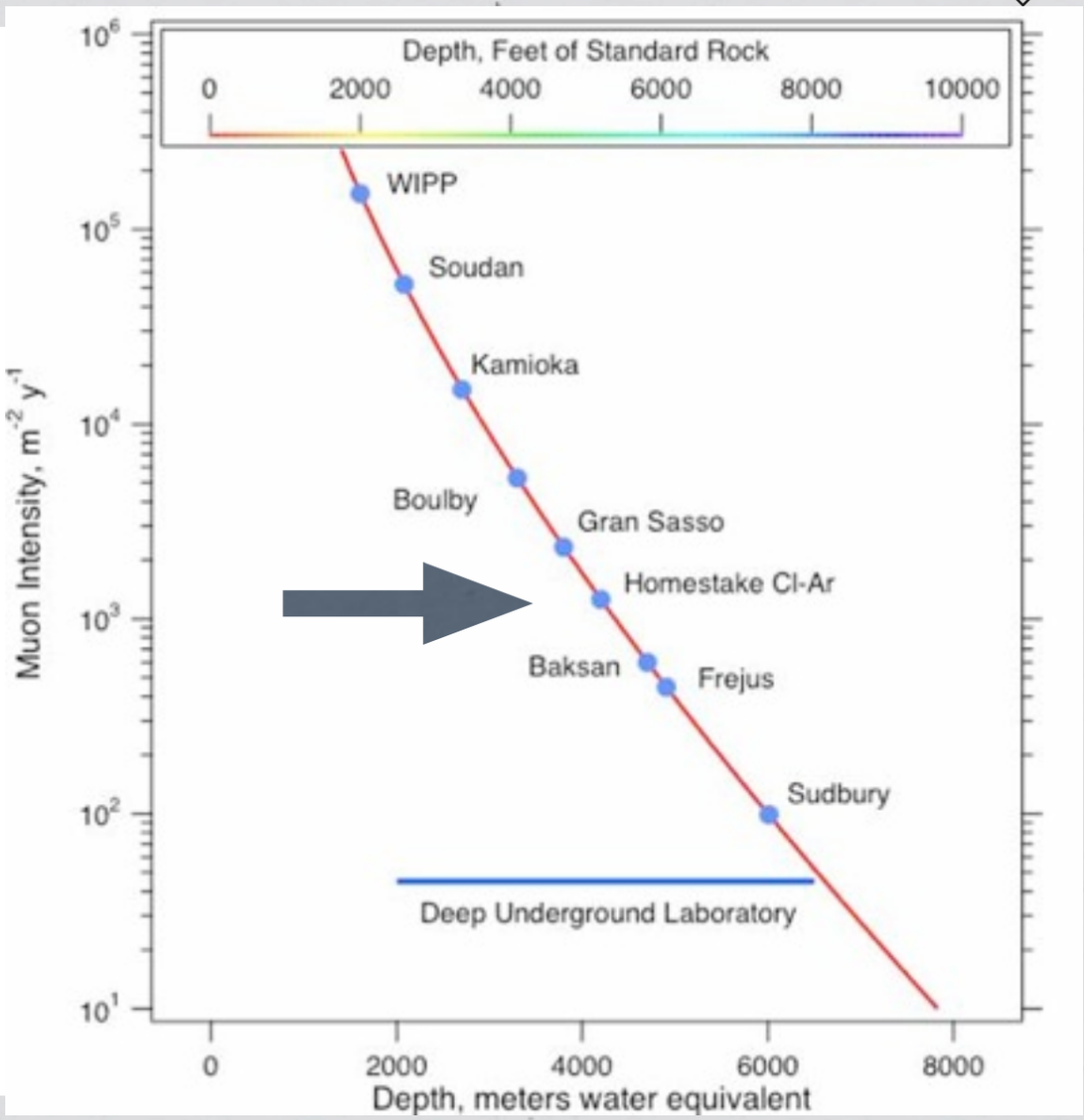
[6]*Physics Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA*

[7]*Physics Department, University of Maryland, College Park, MD 20742*

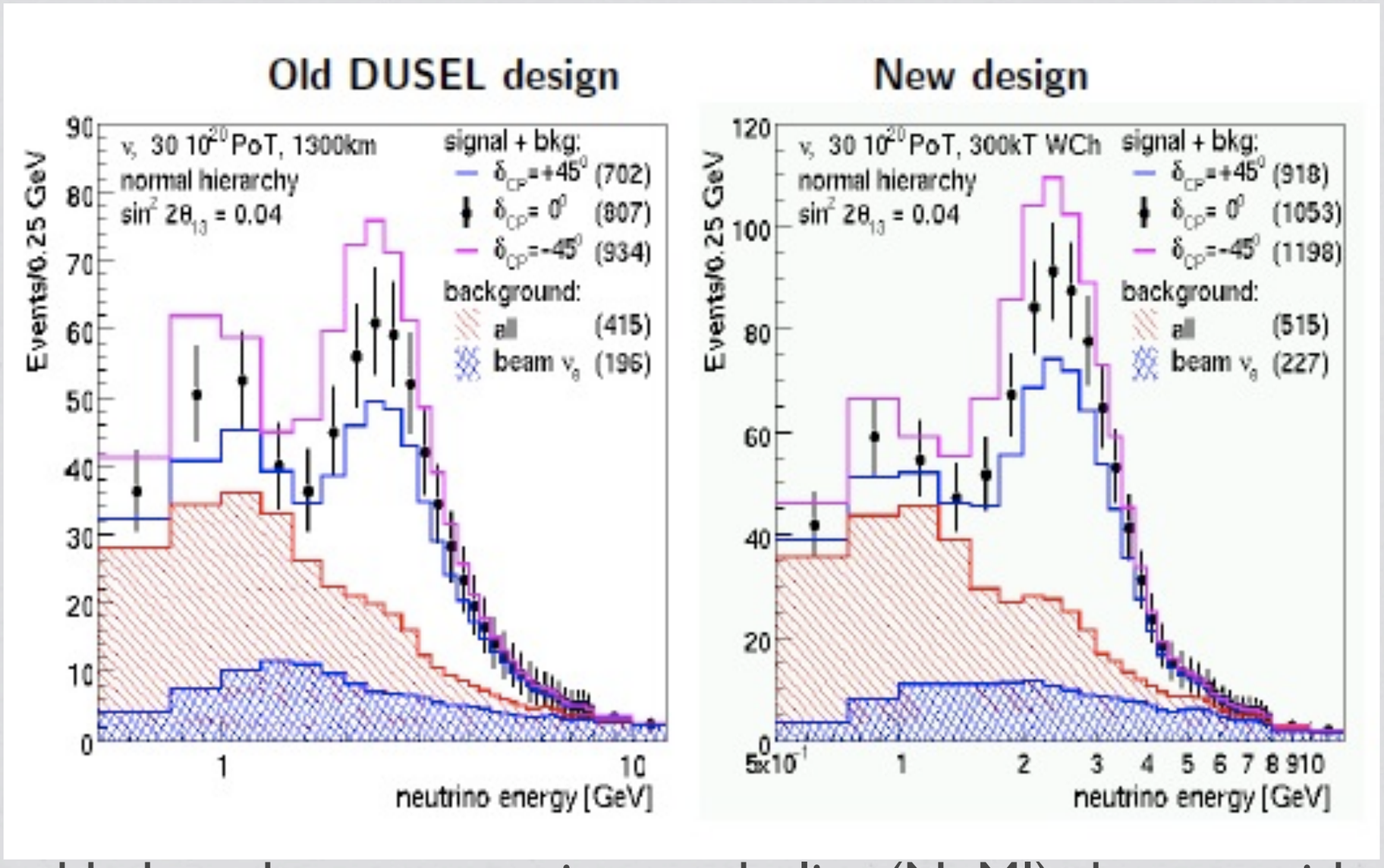
[8]*Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, PA 19104*

[9]*Department of Physics, California Institute of Technology, Pasadena, CA 91125*

[10]*Particle Physics Division, MS 220, Fermilab, Batavia, IL 60510*

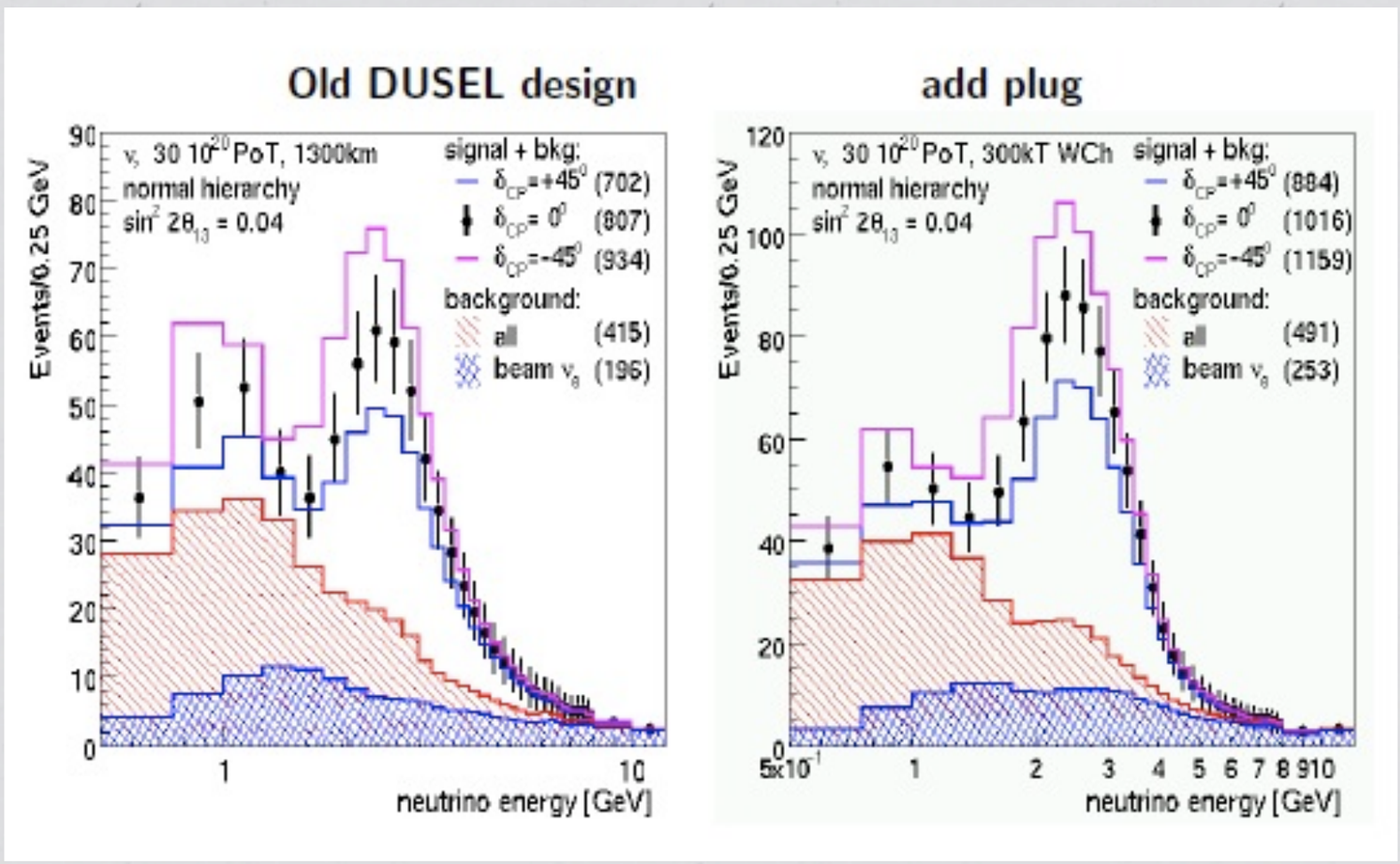


Beam optimization

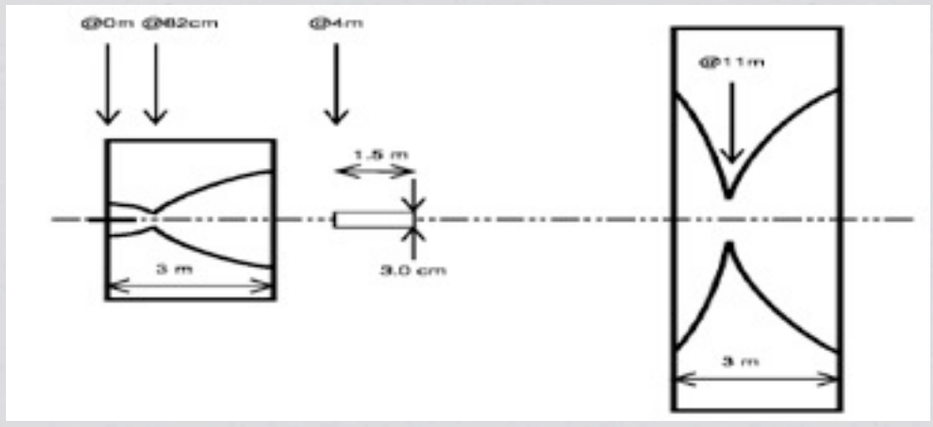


Embedded carbon target in parabolic (NuMI) horns with 6 m separation, cylindrical decay pipe with 4m diameter, 380 m length, 120 GeV.

Further optimization



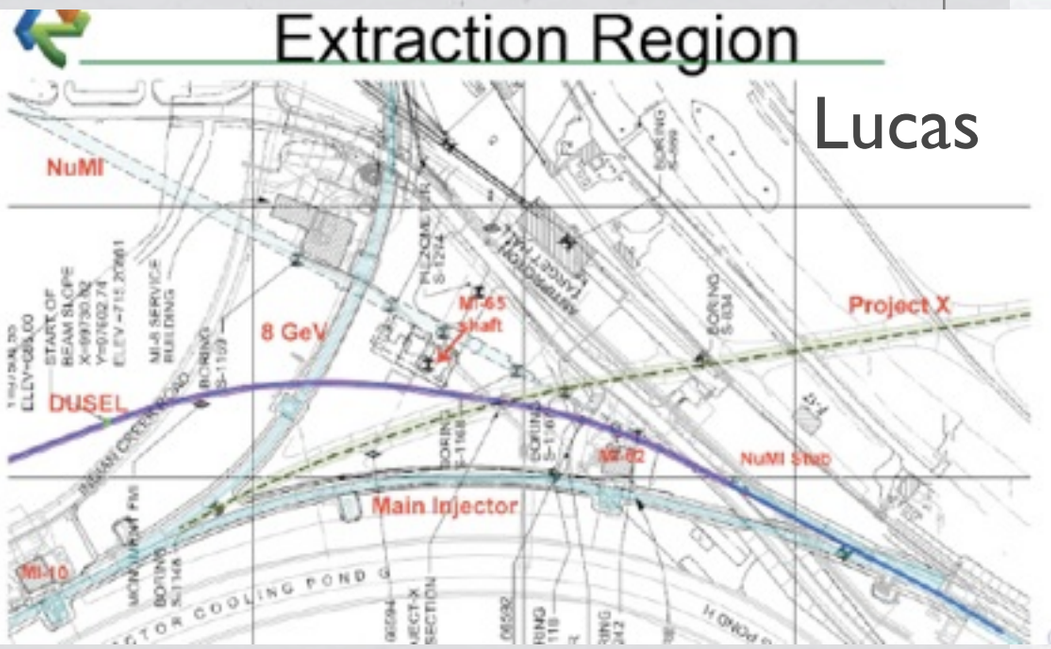
The new design is on-axis.



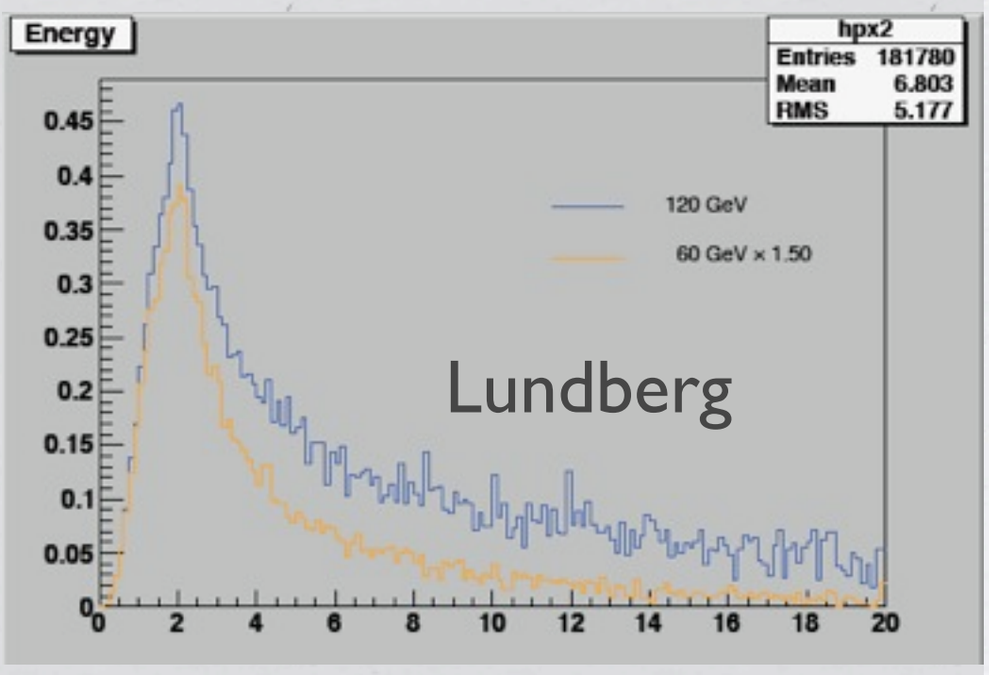
Signal/background enhanced by ~20-30%. Other optimizations (proton beam energy) under investigation in the beam working group.

Beam working group

Childress



Lucas



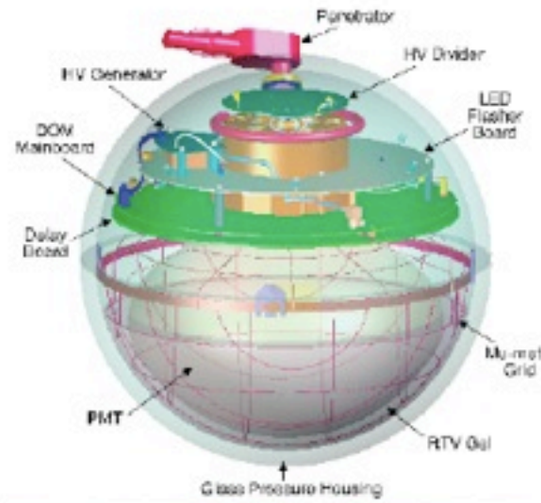
Lundberg

Beam Working group is run by Jeff Appel and meets every Monday. Approximately 15-20 members, apologies for the short mention.

Phototubes and Electronics

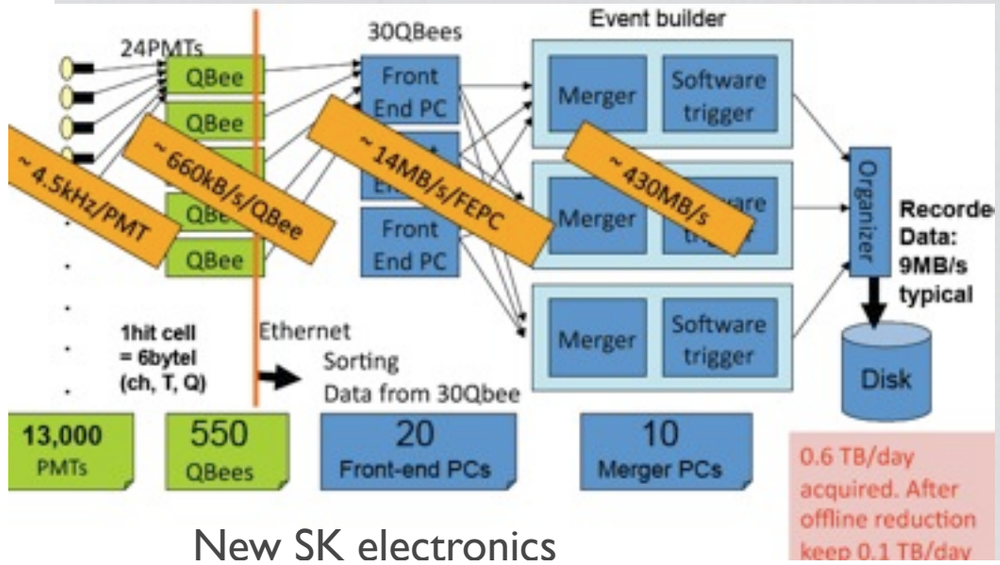
78 high quantum efficiency 10”PMT successfully tested for use in IceCube

- More than 4000 sensors with standard 10” PMT (R7081-02) integrated and tested in IceCube
- 78 high quantum efficiency PMT (10”) tested with IceCube standard production test program.
- Result:
  - Quantum efficiency ~38% higher (405 nm, -40C)
  - No problems found
  - Low temperature (-40C) noise behavior scales with quantum efficiency as expected.
- Deployed all modules in the ice this past season



A. Karle, UW-Madisc

A. Karle, UW-Madison



New SK electronics

- QTC custom IC and QBEE module designed by Iwatsu Electric Co. in collaboration with scientists from ICRR/U. Tokyo. Development costs seem to be mainly supported by ICRR. QBEE is a quasi-commercial product – eg. RENO is using ~ 50.
- Ethernet daughtercard designed by Boston University. Detailed interface specification exchanged with Iwatsu. Successful collaboration.
- Our (U.S. SK collaborator) marginal cost was $130/ch.

Work on water system, materials, additives also proceeding: UCI, LLNL, Davis, IPMU

E. Kearns

Sanford Laboratory Status

Aerial View of Homestake

Sanford Lab progress

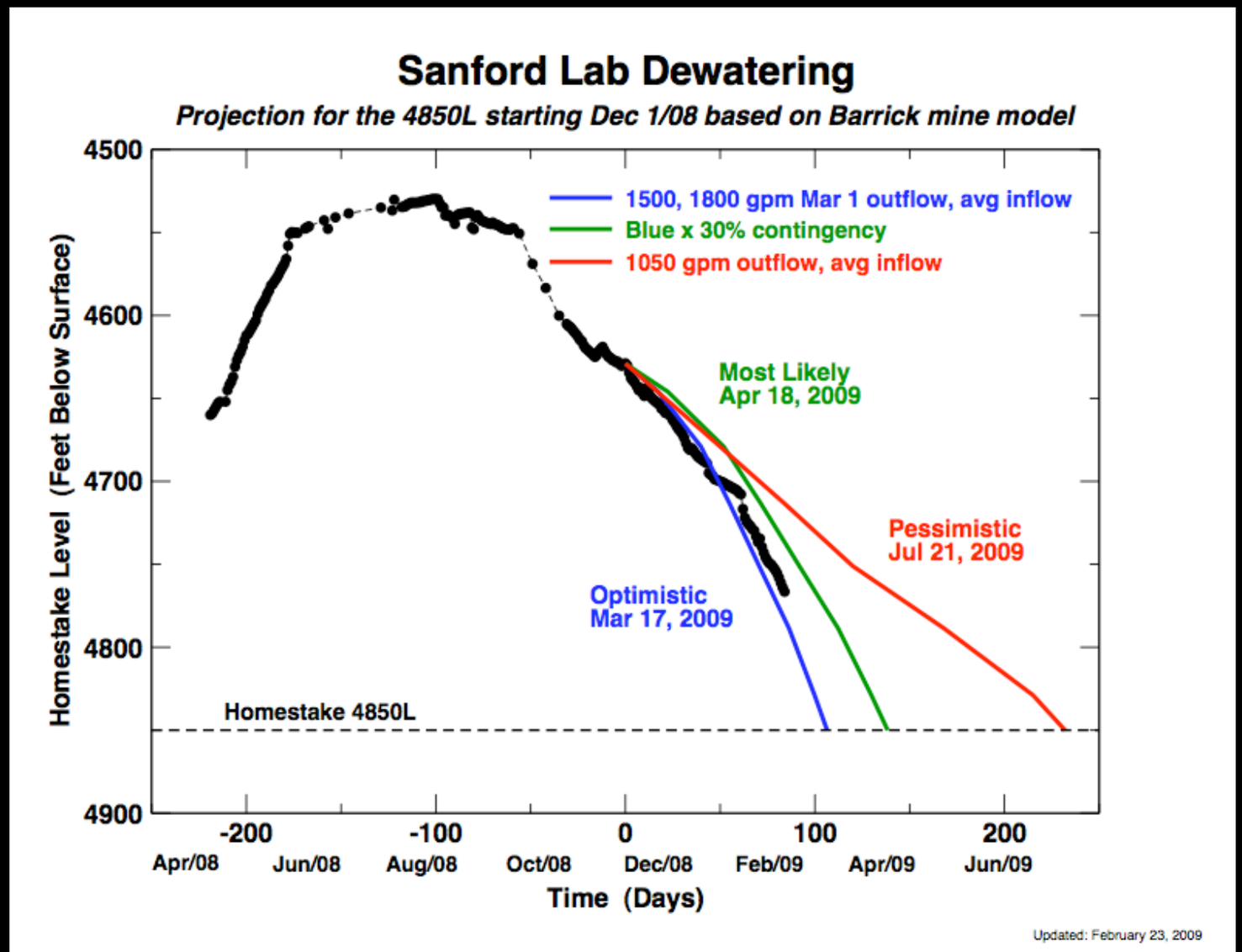
* October 2007: 6 staff
* Feb. 2009: 68 full time, 26 part time, 25 contract staff onsite.
* Access to new mine levels carried out in steps
  * Inspection by expert, experienced crew
  * Evaluation of Risk, develop maps for allowed access
  * Mitigation plans for more extensive access
  * Water draining: restart stationary pumps, install submersible pumps

Pump Re-Installation

Re-commissioning
of pump chain
to begin de-watering

4550L Submersible Pumps in Action

Making progress!



Water level 2/26 …… 4775 (feet below surface)

First year Review of the Cooperative Agreement between NSF & U. C. Berkeley for DUSEL

- UCB, January 27-29, 2009
- ~ 40 Reviewers in 6 disciplines, E. Temple Chair.
  - SC-1: Surface and Underground Construction
  - SC-2: Underground Experiments.
  - SC-3: Education and Outreach
  - SC-4: ES&H
  - SC-5: Costs and Schedule
  - SC:6 Project management
- DOE representatives present.

SC-2 Underground Experiments Committee
Allison Lung, TJNAF (Chair)
Charles Dowding, Northwestern
Abe Seiden, UCSC
Moira Ridley, Texas Tech
Mike Witherell, UCSB
Marty Breidenbach, SLAC

Following slides are from (or as a consequence) of this review
Supplied by RW Kadel

Current Resources for DUSEL Preconstruction Planning and Development

- NSF Solicitations and Funding Opportunities
  - S-1: Assess the Science -- Deep Science - December 2006
  - S-2: Produce Site - specific Conceptual Designs - July 2007
  - S-3: Select a site -- Homestake
    - $15M - 3 year Cooperative Agreement with UCB - September 2007
    - *$3M Supplemental Funding Request: Large Cavities - submitted FY09*
  - DUSEL Experiment Development Committee (DEDC) Grant
    - $700k - 2 years - August 2008
  - S-4 Develop Designs of Potential Experiments
    - *$15M - 3 year - Proposals Due January 2009*
  - S-5 Select Experiments
- South Dakota Efforts
  - $115M (State-controlled and Philanthropic Sources)

Current DUSEL Outsourced Site Investigation and Design Contracts

- Geotechnical Engineering (contractor selected, work begun)
  - Perform Coring, Lab Testing, *In situ* Testing
- Infrastructure Due-Diligence Inspections & Preliminary Design (contractor selected)
  - Determine Status of Infrastructure
  - Scope Definition and Basis for Design
  - Produce Preliminary Design Documents
- Excavation Design (RFP anticipated FY09)
  - Develop Plans for the Creation of Lab Module Excavations
- Surface Building Assessment and Preliminary Design (RFP 09)
- Large Cavities (S3 supplemental funding request FY09)
  - Perform Initial Geotechnical Engineering
  - Develop Excavation Design Concepts

Contracts are administered through the SD School of Mines

South Dakota and Sanford Lab Participation in Preparing for DUSEL

- Major Financial Support from the State of South Dakota
  - $35M from State General Fund
  - $10M HUD grant
  - $70M from Philanthropic Donation (T. Denny Sanford)
  - SDSTA Owns the Property (Donation from Barrick)
- Partnership to “achieve DUSEL” at the Homestake mine
- DUSEL assimilates Sanford Lab at MREFC Construction
- Facility Work Initiated (Site Preparation and Risk Reduction)
  - Rehabilitation of Surface and Underground Infrastructure
    - Lifts & Shafts
    - Pumps
    - Facility Stabilization and Rehabilitation
    - Initial Operations, Environment, and Safety Programs
    - Early Science Program
  - Rock Disposal Sites - *Agreement in Principal* with Barrick to use the “Open Cut”, alternative sites identified

SDSTA Accomplishments (abbreviated list)

- Ross Shaft rehabilitated to water level. ($9.2 million)
- Ross Hoist re-certified and operating.
- Yates Shaft rehabilitation in process. ($9 million bid awarded)
- Yates Hoist is re-certified and operating.
- Current water level is 4775 feet below the surface (2/26/09), down from a high water mark in August 2008 of 4,529 feet.
  - Pumping capacity from the mine is 1500 gpm.
  - Water Treatment capacity is 2000 gpm.
  - Plans to upgrade pumping capacity to 2000gpm with backup pumps

100kT Fiducial Volume Cavern Cost estimate

Laurenti, FNAL 2008 Aug 1($Millions)

- Cavern excavation: 33.1
- Equipment 10.0
- Overhead (10%) 4.4
- Markup(20%) 8.7
- Contingency (40%) 22.8
- Skipping cost ($4/Ton) 2.0 (500 kT)
- Disposal ($10/Ton) 5.0 (500 kT)
- TOTAL $86.1M (1 cavern)

Costs associated with geotech work has been removed from Laurenti's estimate. DUSEL pre-construction budget for the Large Cavity (including geotech work) is shown below.

$3M is proposed to be a supplement to the S3 award to start this work. Perhaps get us to CD1.

	FY09	FY10	FY 11	FY12	Pre-construction Totals
Total Expenses ($K)	1459	3378	4687	5314	14838
Staffing ($K)	232	1213	1372	1489	4306
Contracts ($K)	1227	2165	3315	3825	10532
Staffing (FTE)	0.3	4.5	4.5	5	14.3
LBNL (FTE)	0.3	2	2	2	6.3
SDSMT(FTE)		2.5	2.5	3	8

Large Cavity Schedule

- CY2009
  - Numerical Analysis (FEA) various cavern shapes
  - Mapping, Drilling (~ 3000ft) & Analysis: 4100L & 4850 L
  - Preliminary Hazards Analysis, detectors & excavations
  - Detector Conceptual Design Report (VLBL Collaboration, end of CY)
- CY2010
  - Supplementary Drilling (~ 3000ft) or Drifts & Analysis 4850L
  - Cavity Modeling based on Cores
  - Preliminary cavern design, cost estimate (end of CY)
- CY2011
  - Definition Drilling (≥ 6000ft) or Drifts & Analysis: 4850 L
- CY2012
  - Cavern Final design & Cost estimate (end of CY).

This plan will evolve with input from the Large Cavity Advisory Board (LCAB)

Large Cavity Advisory Board

Ed Cording Evert Hoek John MacDonald Derek Martin

The Large Cavity Advisory Board (LCAB) was established in January 2008 to provide technical expertise and advice to the DUSEL project directorate on issues of siting, excavation, excavation stabilization and monitoring of large-scale excavations at significant depth in Homestake. All members have experience in the design and construction of large underground cavities in a wide range of rock mass and in situ stress conditions.

The LCAB will report to Kevin Lesko in his capacity as DUSEL Principal Investigator, UC Berkeley.

SC-2 Technical Review: Large Cavity Experiments (paraphrased)

- Findings
  - Science is well motivated
  - Integration issues understood in terms of depth requirements, size and interface between the two possible experimental techniques and the facility
- Comments
  - Significant progress
  - List of integration issues appropriate for project status.
  - Congratulations to DUSEL team and collaboration for identifying science requirements for experiment and facility infrastructure.
- Recommendations
  - None.

Collaboration status

* Institutional Board formed
* Adapted first set of bi-laws (at UC Davis)
* An executive board is in operation.
* The S4 proposal is very important for this collaboration. It is a well coordinated proposal.
* Approximately 50 people are now active, but waiting for funds. More about funds later…

ANL:M. Goodman
Boston: E. Kearns
BNL: M.Diwan
Caltech:R. McKeown
UC Davis: R.Svoboda
UC Irvine: H.Sobel
UCLA: H.Wang
Chicago: E.Blucher
Colorado State:N.Buchanan
Columbia:L.Camilieri
Drexel:C.Lane
Duke:K.Scholberg, C.Walter
FNAL:R.Rameika
Indiana:M.Messier
INFN(Catania): R.Potenza
Kansas State: T.Bolton
LLNL: A. Bernstein
LBL: R.Kadel
LSU: T.Kutter
Maryland: G.Sullivan
MIT: J.Conrad
Minnesota: M.Marshak, W.Miller
Minnesota(Duluth):A.Habig
Penn: K.Lande
Princeton: K.McDonald
RPI: J.Napolitano
S.Carolina: C.Rosenfeld
Tufts: H.Gallagher
Wisconsin: K.Heeger
Yale: B.Fleming
IPMU: M. Vagins

Science Collaboration

Interim Science Coordinator
Bob Svoboda

Interim Project Coordinator
Milind Diwan

Institutional Board
Chair: Marvin Marshak
Vice-Chair: Maury Goodman

Interim Executive Board
Chair: Ed Blucher

WC WG
Milind Diwan

LAr WG
Bonnie Fleming

Beam WG
Gina Rameika

Other WG
…

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Gina Rameika

Other WG
…

Please….no more boxes….

Interim Informal Organization

Science Collaboration (DOE and NSF*)

informal

BNL Detector Project Office (DOE)

Project Coordination Group

CCC committee
SC/S3 Liaison: (R.Kadel)

DUSEL S3 at LBL (NSF) (incl. SDSTA)

informal

FNAL Project Office (DOE)

*** via S4 requests, no request to DOE yet**

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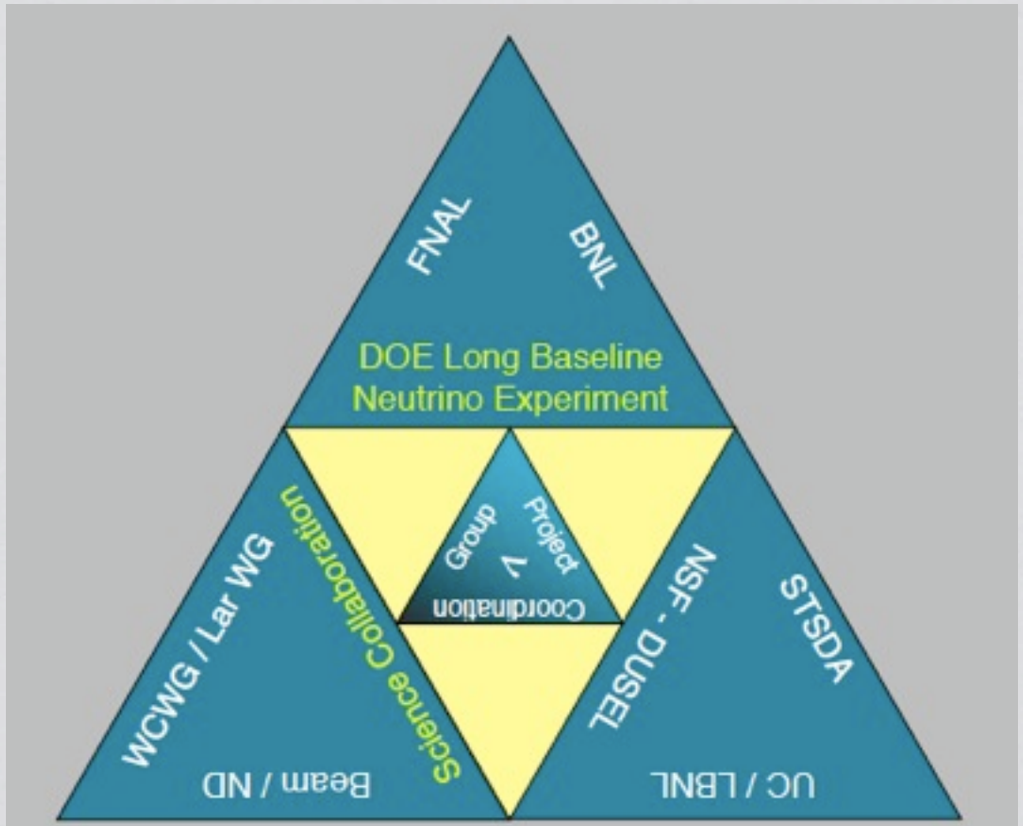
*** via S4 requests, no request to DOE yet**

....yet?

CD1 preparation

- Project Coordination Group formed
- WBS is being made
- FNAL will have the main office. Funding for CD1 will probably amount to $2-4M for beam, detector, each.
- Crucial to avoid duplication and/or holes.



All stakeholders

Request from DOE

We would like to see Fermilab and Brookhaven form a well integrated, effective team to **develop the CD1 documentation for a Long Baseline Neutrino Experiment (LBNE).** The LBNE is comprised of a neutrino beam line, a near detector, and a far detector. The target **time frame for completion of the CD1 documentation is the third quarter of FY 2010**.

Water Cherenkov

Task	DOE CD1	S4	S3 Cavern	Other requests
PM	2.2			
reserve	1.8			
Integration	0.7			
CivilIntegration	1.2	0.06	2.1	1.3
Vessel	0.4			
PMT support	0.2	1.1		
Magnetic supp.	0.4			
PMT	1.1	0.9		0.6
Calibration	0.1	0.1		
Electronics	0.25	0.25		
OfflinSimulatio	0.2	1.3		
Water System	0.4	0.2		
Installation	0.6			
Total	~10-12	~4	~2	~2

$M

Preliminary

* We are preparing a coordinated plan between DOE, S4 request, S3 request and other proposals. This is a sum for FY09 and FY10. S4 continues to year 3 with another $2M. There is no duplication in this plan: IF NOT FUNDED BY NSF, NEED TO MOVE ITEM TO DOE COLUMN and vice versa. In any case, the cavern design is not yet adequately funded.

People, people, people

* The plan is to have project management people at FNAL and BNL, but distribute the rest, but laboratory engineering is essential to assure engineering standards are followed.

* S4 will be known in a few months. S4 includes large number of students and postdocs.

* On the DOE side need to ramp up to 6 FTE in FY2009, and then another 10 in FY10. Also supports postdocs.

* National Lab. managements need to consider how to do this. We know how to coordinate such efforts.

A few words on Argon

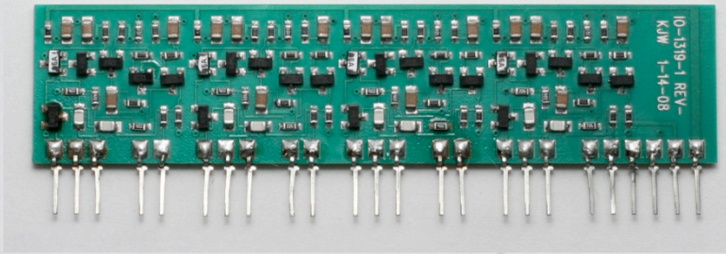
* The LAR S4 now focuses on building a 5 kTon device in one of the long halls.

- Develop an S5 Proposal for a 5 kT LAr Detector by late Winter/early Spring 2010
- Make progress on research, engineering, design regarding major components of S5 Proposal
  - Physics capabilities of LAr Detectors
  - Ability to design, estimate cost and manage the construction and installation of a 5 kT LAr Detector
  - Ability to design, estimate cost and manage the interface between the 5 kT LAr Detector and DUSEL
  - Ability to demonstrate safe installation and operation of a 5 kT LAr Detector
- Key issues for Detector Design
  - Cryostat: How many? Vacuum or foam insulation. Foam cheaper to construct but has more heat leaks, microphonics, cannot be initially evacuated [Indiana]
  - Electronics: Cold electronics reduces cabling issues and cost, but requires operation with high reliability in hostile environment [BNL/Michigan State]
  - TPC, PMT and HV: need long drifts [large voltages], reliable triggering [UCLA]
  - Argon Purification: Need to achieve high purity to sustain long drifts [Entire Collaboration]

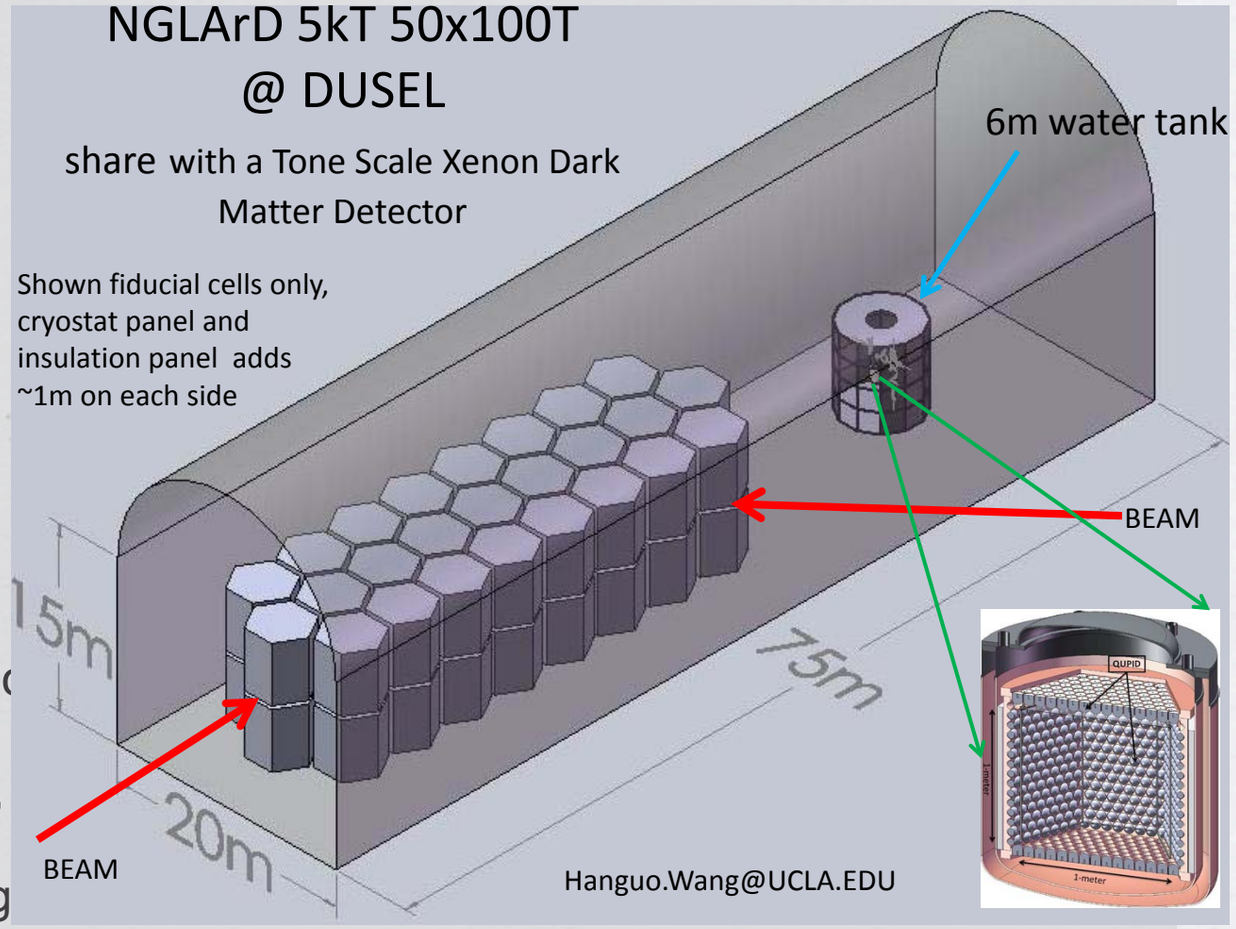
A similar coordinated budget for CD1 is in preparation. Will need a separate talk.

Question remains: what fraction is to be generic detector R&D ?

Some technical LAR development



- Cold Electronics in LAr greatly improve the signal to noise ratio of the ionization signal; provide the flexibility in the TPC configuration.
  - With highly multiplexed readout, cost vs. channel count curve flattens
  - Need to limit the power density of the ASIC to prevent bubbling
- The diffusion constants (both transverse and longitudinal) have great impact on the performance o the detector, and need to be measured soon.
  - TPC parameters, such as wire pitch, wire plane spacing, and maximum drift length
  - Electronics parameters, such as dynamic range, shaping time, sampling frequency, bandwidth



Concept for deployment


There’s real gold
at the end of this rainbow!